Influence diagrams and scoping for Life Cycle and Sustainability Assessment, an example from sustainable mining

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1. Introduction

Life Cycle Assessment is a technique typically intended to provide a holistic assessment of environmental and possibly also social impacts over the entire supply chain and life cycle. However, LCA has limitations, for a variety of reasons:

- LCA is not well able to deal with risk and chances
- LCA typically does not model local situations in high resolution, and thus tends to overlook specific local conditions
- LCA is a rather technical approach with high data needs, which are especially difficult to satisfy in regions where LCA is new and no background databases are available; as a consequence, immediate improvement in perilous situations might be better achieved with more “hands-on” tools
- LCA results have the issue to be difficult to understand, and recent alternative approaches such as the circular economy are gaining attraction.

In this situation, it is interesting to investigate, for a given issue, the ideal portfolio of tools to be used, including, but not necessarily limited to, LCA. Moreover, in every LCA, it is in a first step important to specify goal and scope for the further analysis, and it is worthwhile to be aware of aspects which have an influence on the overall environmental impacts of an investigated product. So far, goal and scope in LCA is conducted typically without a diagram or visualization of relations between different aspects to be decided about in goal and scope.

We introduce influence diagrams and advanced hot spot analysis as a means to both “tailor” the approaches to be applied for assessing the sustainability of a given situation, and also to shape goal and scope of an LCA, where LCA is part of said portfolio.

2. Materials and methods

Causal loop and influence diagrams are a common tool in modelling and systems analysis and often described in literature [1-3]. They typically serve to better understand the system under study, and more specifically to identify elements in the system that have a stronger influence on system results and, ideally, also on system stability.

A typical use of causal loop diagrams is qualitative modelling, they help in structuring a topic, and thus can be used as first step of a more detailed analysis and system assessment. Despite these points, applications to Life Cycle and Sustainability Assessment are scarce to non-existent.

We develop and present a causal loop diagram for sustainability assessment of mining in general, and apply this to specific mine sites in Finland, Portugal, and South Africa, where this approach is currently applied, led by GreenDelta, in the European H2020 research project ITERAMS.

3. Results and discussion

For the diagram, we developed specific archetypes, i.e. elements with a specific function, which are adapted to the specific idea of modelling sustainability impacts. These archetypes are:

- endpoints: Endpoints are impacts on human health, ecosystems, and so forth (Fig. 1)

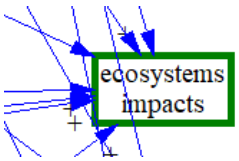

Figure 1: Ecosystems impacts as one of the endpoints in the diagram.

- life cycle connection points: The model primarily addresses the mine, which makes sense as the remaining life cycle model is linear; life cycle connection points are used to link “local” requirements of the foreground, mine system to the supply chain

- arrows are used to show relations, a positive relation between a and b means that with an increase of a, b increases; a negative relation means that with an increase of a, b decreases (Fig. 2)

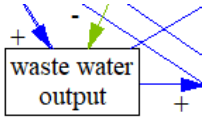

Figure 2: Arrows showing positive (blue) and negative (green) relations in the diagram.

- further elements in the diagram are input variables, conditions that cannot be changed but have impact on results potentially, stocks within the system (which include in-system variables with a certain value) and risks as a specific type of stocks

An analysis of the diagram shows relations within the system, and hot spots and main drivers for impacts. Fig. 3 shows a simple example for contribution to land use impacts from a mine.

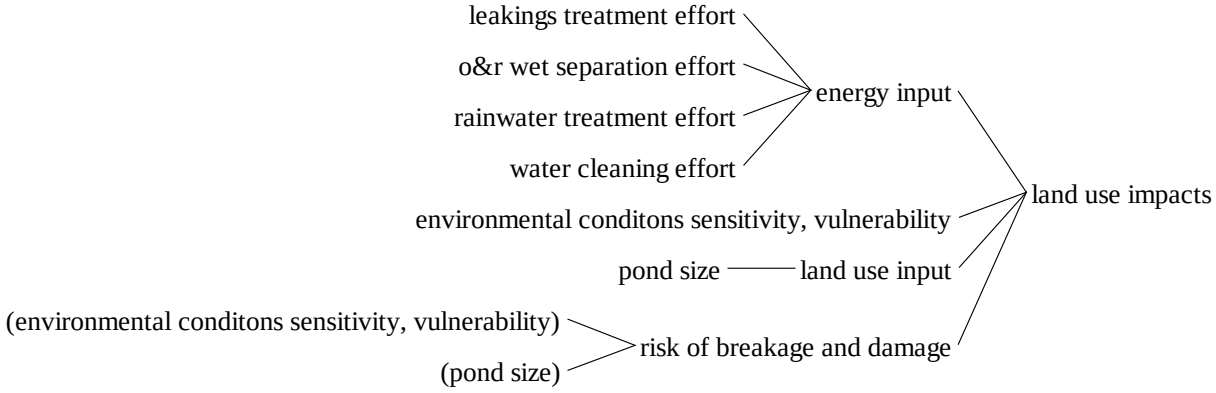

Figure 3: causes for land use impacts of a generic mine.

The analysis also shows which tools are suitable for addressing the hot spots and main drivers which exist according to a defined broader goal and scope, considering a portfolio of environmental life cycle assessment to social life cycle assessment to analysis of economic performance to risk assessment; and also the more regional approaches, such as Environmental Impact Assessment and Social Impact Assessment, can contribute important insights.

4. Conclusions

In the presentation, the developed causal loop diagram and the approach for obtaining the diagram for the case will be explained, with results from the ITERAMS project. Results are quite promising and we believe that using causal loop diagrams in sustainability and life cycle assessments helps to clarify selection of the (combination of) appropriate tools for the assessment, and further, helps to structure the goal and scope setting in LCA.

5. References

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